Enhancing NCEP-NAM Weather Forecasts via Assimilating Real-time Green Vegetation Fraction

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ABSTRACT

Accurate forecasts of temperature and precipitation from numerical weather prediction (NWP) models rely on the quality of the initialization of land surface state variables (e.g. soil moisture(SM)) and the representativeness of parameters that describe the current land surface (e.g. green vegetation fraction (GVF)). Real time satellite-based land surface products are capable of providing spatially continuous observations of surface parameters while accurately capturing the dynamics of surface conditions. Studies have shown the value of real time vegetation cover information and the feasibility of assimilating vegetation dynamics products into the land surface models (LSMs) to improve the land-atmosphere water and energy exchange simulations (Fang et al., 2014). Current NCEP Noah LSM within the NCEP North American Mesoscale Forecast System (NAM) uses only a multiyear climatology of GVF although land-atmosphere interactions are well known to be sensitive to realistic vegetation status.

This study aims at assessing the impact of assimilating real-time satellite based GVF on the weather forecasts of the NCEP NAM model.

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Introduction

The exchange of energy and water fluxes in operational NWP models is very sensitive to **green vegetation fraction (GVF)**, an important weighting coefficient in partitioning total evapotranspiration into the three components of evaporation (Gutman and Ignatov, 1998). GVF is also a highly variable parameter annually and seasonally (Chen et al. 2001). More importantly, a successful assimilation of LST information into land surface models (LSMs) is dependent on a consistent representation of the observed vegetation fraction. However, the current Noah LSM (Ek et al., 2003) within the NCEP North American Mesoscale Forecast System (NAM) utilizes a multi-year climatology of GVF. Climatological GVF maps are not always representative of the actual condition observed on the ground (e.g., in regions of drought; early or late emergence/senescence), especially in agricultural areas of the central and eastern U.S., where temporal variability in GVF can be significant. Fang et al. (2014) compared Noah LSM SM estimates using either the multiyear climatology or real time GVF and found the later could improve Noah LSM performance.

This study aims at assessing the impact of assimilating real-time satellite based GVF on the weather forecasts of the NCEP North American Mesoscale Forecast System (NAM) NAM model.

Data and Model

❖ GVF Climatology and NRT GVF

	Temporal Resolution	Spatial Resolution	Data Source
GVFc	Static 5-year avg	0.144 deg	AVHRR
GVFR	4-day composite	1 km	MODIS
C: climatology; R: near-real-time			

❖ NU-WRF

- NASA Unified-Weather Research and Forecasting (NU-WRF) Version 7
- A fully coupled NASA LIS and the standard NCAR Advanced Research WRF (WRF-ARW) assimilation system
- Installed and tested on S4 supercomputer

❖ Model Evaluation Tool (MET)

- Point-Stat
  - provides verification statistics for forecasts at observation points
- Grid-Stat
  - provides verification statistics for a matched forecast and observation grid

❖Validation dataset

Variable	Temperature (2-m)	Relative Humidity (2-m)	Precipitation
Dataset	PrepBufr for GDAS	PrepBufr for GDAS	NCEP National StageIV Precipitation
method	Point Statistic	Point Statistic	Grid MODE

Methodology

❖ Two NU-WRF runs are performed using climatology GVF and near-real-time GVF as input while other meteorological forcing parameters are kept the same

❖ Studying period: April 1st – Oct. 31st, 2012

❖ Forecasts of 2 m surface temperature of the two runs are validated using in situ observations

Results

❖ Differences in GVF and Tmp-2m forecast

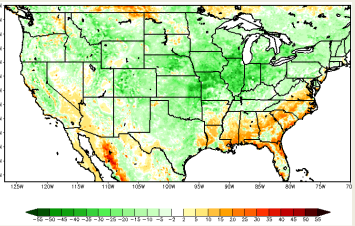

Fig. 1. The average GVF differences between NRT GVF and climatology; NRT minus climatology; over July, 2012

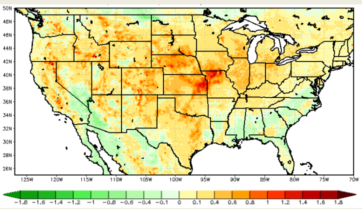

Fig.2. Differences in 2 m surface air temperature (unit: K) by using NRT GVF and using GVF climatology (NRT minus climatology); over July, 2012

❖ Validation of Tmp-2m forecast against In-situ

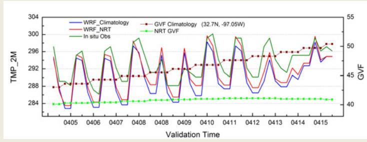

Fig.3. Time series of 2 m surface air temperature forecast from NUWRF with NRT GVF and climatology; along with in-situ observations; at (32.7N, -97.05W) over April 4th – 16th

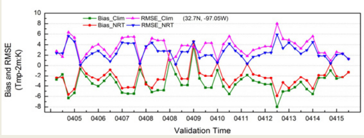

Fig.4. Bias and RMSE in 2 m surface air temperature forecast from NUWRF with NRT GVF and climatology; at (32.7N, -97.05W); over April 4th – 16th

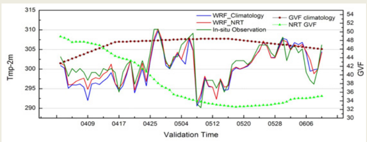

Fig.5. Time series of 2 m surface air temperature forecast from NUWRF with NRT GVF and climatology; along with in-situ observations; at (31.18N, -99.32W) over April 4th – June 8th

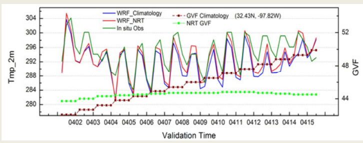

Fig.6. Time series of 2 m surface air temperature forecast from NUWRF with NRT GVF and climatology; along with in-situ observations; at (32.43N, -97.82W) over April 1st – 16th

Regional Verification

❖ NUWRF TMP-2m forecasts are validated against ground observations over the warm season (April to Oct., 2012)

❖ 1935 sites in total over CONUS domain

❖ Validated over full CONUS domain and sub-regions

❖ MAE and RMSEs of WRF forecasts using climatology and NRT GVF were compared spatially and temporally

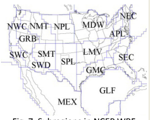

Fig. 7. Subregions in NCEP WRF-NMM forecast verification system

❖ Verification over LMV sub-region

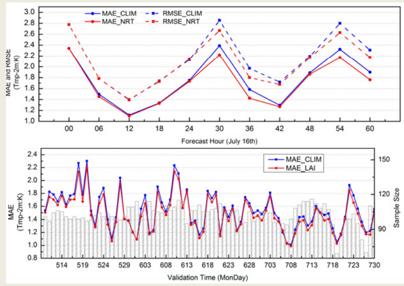

Fig. 8. MAE and RMSE in 2 m surface temperature for LMV region (a) over 60h forecast on July 16th; (b) over the period of May to July

❖ Verification over NWC sub-region

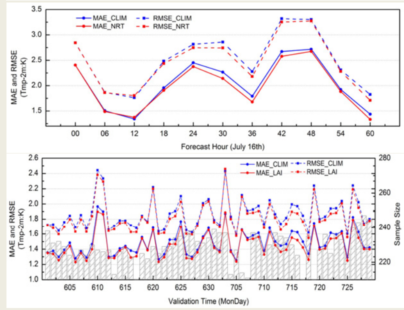

Fig. 9. MAE and RMSE in 2 m surface temperature for NWC region (a) over 60h forecast on July 16th; (b) over the period of June to July

Region ID	Region Name	Total number of validation sites	Sites with improvement (in percentage)
1	NEC	190	90.00
2	LMV	205	53.17
3	APL	100	77.00
4	MDW	472	50.85
5	NWC	85	67.06
full	CONUS	1935	57.67

Conclusions

❖ Validation results show positive impact of NRT GVF on the improvement of NU-WRF forecasts. The results are physically sound as 2 m surface temperature forecast using NRT GVF increases in response to the negative anomaly compared to GVF climatology (Fig. 1 and Fig. 2), and vice versa.

❖ The using of NRT GVF, which is more representative to the reality of surface green cover, can significantly reduce the bias (both warm and cool bias) in model forecasts compared to the run using multi-year average GVF.

❖ In summary, overall improvements were gained with the use of NRT GVF by reducing the bias and RMSE, compared to the use of GVF climatology.